Left-Right Asymmetry of the Weak Interaction Mass of Polarized Fermions in Flight

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Abstract: The left-right polarization-dependent asymmetry of the weak interaction mass is investigated. Based on the Standard Model, the calculation shows that the weak interaction mass of left-handed polarized fermions is always greater than that of right-handed polarized fermions in flight with the same velocity in any inertial frame. The asymmetry of the weak interaction mass might be very important to the investigation of neutrino mass and would have an important significance for understanding the parity nonconservation in weak interactions.

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1 Introduction

In virtue of the parity nonconservation, the Standard Model (SM) is a chiral gauge theory and all the fermions are completely chiral, which necessarily results in the lifetime asymmetry. The left-right polarization-dependent lifetime asymmetry has been proposed based on theoretical analyzes [1]. The relative ratio of decay probability for moving fermions is given by

$$\frac{\Gamma_{Rh}}{\Gamma_{Lh}} = \frac{1-\beta}{1+\beta}, \tag{1}$$

where Γ_{Rh} is the decay probability, caused by weak interaction, of the right-handed (RH) polarized fermions and Γ_{Lh} is that of the left-handed (LH) polarized fermions. The concrete calculation for decays of polarized muons has also been carried out within the framework of the SM [2, 3]. The result shows that LH polarized fermion lifetime τ_{Lh} is different from RH polarized fermion lifetime τ_{Rh}, i.e.

$$\tau_{Lh} = \frac{\tau}{1+\beta} \quad \text{and} \quad \tau_{Rh} = \frac{\tau}{1-\beta}, \tag{2}$$

where τ is the average lifetime, $\tau = \gamma\tau_0 = \tau_0/\sqrt{1-\beta^2}$, β is the velocity of the fermions measured in a natural system of units in which $c = 1$ and τ_0 is the lifetime in the fermion rest frame. It is shown that the lifetime of RH polarized fermions is always greater than that of LH ones in flight with the same speed in any inertial frame. The lifetime asymmetry is conveniently described by the quantity

$$A(L)_{LR} = \frac{\tau_{Rh} - \tau_{Lh}}{\tau_{Rh} + \tau_{Lh}} = \beta. \tag{3}$$

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On the other hand, SLD Collaboration has measured the parity-violating asymmetry in e^-e^+ collisions, in which the electrons are polarized while the positrons are not [4, 5, 6, 7, 8, 9]. SLAC E158 Collaboration has also precisely measured the parity-violating asymmetry in polarized electron-electron Møller scattering [10, 11]. Their results show that the integrated cross section of LH polarized electron beams is greater than that of RH ones in the neutral weak current processes mediated by Z exchange. SLD and E158 experiment have already indirectly demonstrated the lifetime asymmetry. In order to directly test the lifetime asymmetry, some possible experiments have been proposed. [12]

The concept of mass is one of the most fundamental notions in physics, comparable in importance only to those of space and time [13], and has a significant impact on modern physics, from the realm of elementary particles to the cosmology of galaxies. The elementary fermions, leptons and quarks, may have associated finite self-interaction energies which may be responsible for part or all of their masses. Although the value of the masses of the elementary fermions is correlated with the strength of their dominant self-interaction, nondominant self-interactions also must play a role [14]. Therefore, the physical mass m of a particle may be expressed by

$$m = m(b) + \Delta m(s) + \Delta m(em) + \Delta m(w), \tag{4}$$

where $m(b)$ is the so-called bare mass, $\Delta m(s)$, $\Delta m(em)$ and $\Delta m(w)$ are the strong, the electromagnetic and the weak interaction mass, respectively. The physical mass m is a quantity which can be measured experimentally and also called the mechanical mass, the gravitational mass or the inertial mass.

From the view point of relativity, an event is described by four dimensional coordinates, three spatial coordinates and one time coordinate. Because the time is also a generalized coordinate, its corresponding generalized momentum is the energy of a particles and the mass is shown to be a form of the energy, the lifetime asymmetry would necessarily result in the asymmetry of the weak interaction mass.

In this paper, we would like to investigate the left-right polarization-dependent weak interaction mass asymmetry. The outline of the paper is as follows. In Sec. 2 and 3, we calculate the weak interaction mass caused by neutral and charged weak current, respectively. The result shows that the weak interaction mass of LH polarized fermions is always greater than that of RH ones. Sec. 4 explores the impact of the weak interaction mass asymmetry on neutrino mass. In last Section, the results above are briefly summarized and its significance is discussed.

2 The Weak Interaction Mass Caused by Neutral Weak Current

The weak interaction mass can be calculated by using the analogical method of calculating the electromagnetic mass. According to the SM, each elementary fermion may emit or absorb elementary gauge bosons connected with its elementary interactions either virtually or really, depending on energy. A free fermion with momentum $\boldsymbol{p}$ and energy E_p, emitting and then absorbing a virtual neutral intermediate vector boson Z with momentum $\boldsymbol{k}$ will acquire an energy which is known as weak self-interaction energy. The intermediate state is comprised of a virtual boson Z and a virtual fermion with momentum $\boldsymbol{q}$ as shown in Fig. 1,

Considering weak coupling of Dirac fields, the total Hamiltonian for a weak interaction

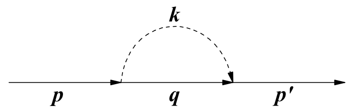

Figure 1: Weak self-energy graph of a fermion.

system is given by

$$H = H_0 + H_I = H_D + H_B + H_I, \quad H_0 = H_D + H_B, \tag{5}$$

where H_D is the free Dirac field Hamiltonian, H_B is the free boson field one and H_I is the interaction one. The interaction Lagrangian density for neutral weak current of elementary fermions is given by [15]

$$\mathscr{L}_I^Z(x) = Q\bar{g}\ \xi\ \bar{\psi}(x)\ \gamma_\mu\ \psi(x)\ Z_\mu(x) - \frac{1}{4}(-1)^{3Q}\ \bar{g}\ \bar{\psi}(x)\ \gamma_\mu\ (1+\gamma_5)\ \psi(x)\ Z_\mu(x), \tag{6}$$

where $\bar{g} = \sqrt{g_1^2 + g_2^2}$, g_1 and g_2 are the coupling constants corresponding to the groups U(1) and SU(2), respectively; $\xi = \sin^2\theta_W = 0.23$; Q is charge number, $Q = 0$ for neutrino, $Q = -1$ for electron, $Q = \frac{2}{3}$ for u-quark and $Q = -\frac{1}{3}$ for d-quark. The $\psi(x)$ is the plane wave solution of Dirac equation. $Z_\mu(x)$ is the neutral intermediate vector boson field. Therefore, the interaction Hamiltonian density is given by

$$\mathscr{H}_I^Z(x) = -\mathscr{L}_I^Z(x), \tag{7}$$

Obviously, the Hamiltonian density $\mathscr{H}_I(x)$ comprises of two terms:

$$\mathscr{H}_I^{(1)}(x) = -Q\bar{g}\ \xi\ \bar{\psi}(x)\ \gamma_\mu\ \psi(x)\ Z_\mu(x), \tag{8}$$

and

$$\mathscr{H}_I^{(2)}(x) = \frac{1}{4}(-1)^{3Q}\ \bar{g}\ \bar{\psi}(x)\ \gamma_\mu\ (1+\gamma_5)\ \psi(x)\ Z_\mu(x). \tag{9}$$

As mentioned above, the SM is a chiral gauge theory. In this theory, all of elementary fermions are divided into two classes, LH chirality state $\psi_L(x)$ and RH chirality state $\psi_R(x)$, in order to describe the parity violation in weak interactions. They are defined as, respectively,

$$\psi_L(x) = \frac{1}{2}(1+\gamma_5)\psi(x), \quad \psi_R(x) = \frac{1}{2}(1-\gamma_5)\psi(x). \tag{10}$$

We see from Eq. (8) that $\mathscr{H}_I^{(1)}(x)$ is not related to the chirality of elementary fermions and thereby can be absorbed into the expression of unperturbed Hamiltonian $\mathscr{H}_0$ by means of the mass renormalization. However, it is not difficult to see from Eq. (9) that $\mathscr{H}_I^{(2)}$ includes the chirality-state projection operator $(1+\gamma_5)$ which can only picks out LH chirality state in a spin state. The posterior discussion will show that it is related to polarization and momentum of fermions. Therefore $\mathscr{H}_I^{(2)}$ can not be cancelled by means of the mass renormalization. We will concentrate on its discussion. Based on Eq. (9), the vertex function corresponding to $\mathscr{H}_I^{(2)}$ is given by

$$i\frac{1}{4}(-1)^{3Q}\ \bar{g}\ (2\pi)^4\ \gamma_\mu\ (1+\gamma_5)\delta^{(4)}(p' - q - k). \tag{11}$$

Now, let us calculate the self-energy process shown in Fig. 1. Applying the Feynman rules, we easily find that the second order probability amplitude for fermion weak self-energy transition from the initial state $|\boldsymbol{p}, s\rangle$ to the final state $|\boldsymbol{p}', s'\rangle$ is given by

$$\begin{aligned}
\langle \boldsymbol{p}', s'|S^{(2)}|\boldsymbol{p}, s\rangle &= -\frac{1}{16}\,\bar{g}^2\frac{1}{V}\frac{m}{E_p}\int d^4q\int d^4k\;\bar{u}_{s'}(p')\,\gamma_\mu(1+\gamma_5)\delta^{(4)}(p'-q-k) \\
&\quad\times\frac{-1}{\gamma\cdot q-im}\;\frac{-i\Big(g_{\mu\nu}-\frac{k_\mu k_\nu}{m_Z^2}\Big)}{k^2-m_Z^2}\;\gamma_\nu(1+\gamma_5)\delta^{(4)}(q+k-p)u_s(p) \\
&= -i\frac{1}{8}(2\pi)^4\,\bar{g}^2\frac{1}{V}\frac{m}{E_p}\delta^{(4)}(p'-p)\;\bar{u}_{s'}(p')(1-\gamma_5)\Sigma(p)(1+\gamma_5)u_s(p), \quad (12)
\end{aligned}$$

where

$$\Sigma(p)=\frac{-1}{(2\pi)^4}\int\frac{d^4k}{k^2-m_Z^2}\left[\frac{\gamma\cdot(p-k)}{(p-k)^2+m^2}+\frac{1}{2m_Z^2}(\gamma\cdot k)\frac{\gamma\cdot(p-k)}{(p-k)^2+m^2}(\gamma\cdot k)\right]. \quad (13)$$

The $u_s(p)$ is the plane wave solution of Dirac equation in momentum representation and known as spin state, in which s is spin indices of spin states and $s=1,2$. In self-interaction process the state of external fermion remains unaltered, therefore Eq. (12) can be rewritten as follows

$$\langle \boldsymbol{p}, s|S^{(2)}|\boldsymbol{p}, s\rangle = -i\frac{1}{8}(2\pi)^4\,\bar{g}^2\frac{1}{V}\frac{m}{E_p}\;\delta^{(4)}(0)\bar{u}_s(p)(1-\gamma_5)\Sigma(p)(1+\gamma_5)u_s(p). \quad (14)$$

However, we have pointed out emphatically that the polarization of fermions must be described by helicity states which may satisfy the ordinary Dirac equation mathematically and are closely relevant to physical interpretation and experimental tests [2]. For LH and RH polarized fermions, therefore, substituting spin states in Eq. (14) with helicity states, we obtain

$$\langle \boldsymbol{p}, Lh|S^{(2)}|\boldsymbol{p}, Lh\rangle = -i\frac{1}{8}(2\pi)^4\,\bar{g}^2\frac{1}{V}\frac{m}{E_p}\;\delta^{(4)}(0)\bar{u}_{Lh}(p)(1-\gamma_5)\Sigma(p)(1+\gamma_5)u_{Lh}(p), \quad (15)$$

$$\langle \boldsymbol{p}, Rh|S^{(2)}|\boldsymbol{p}, Rh\rangle = -i\frac{1}{8}(2\pi)^4\,\bar{g}^2\frac{1}{V}\frac{m}{E_p}\;\delta^{(4)}(0)\bar{u}_{Rh}(p)(1-\gamma_5)\Sigma(p)(1+\gamma_5)u_{Rh}(p). \quad (16)$$

A helicity state can be expanded as linear combination of chirality states:[2]

$$u_{Lh}(p)=\sqrt{1+\beta}\,u_{L2}(p^0)+\sqrt{1-\beta}\,u_{R2}(p^0), \quad (17)$$

$$u_{Rh}(p)=\sqrt{1-\beta}\,u_{L1}(p^0)+\sqrt{1+\beta}\,u_{R1}(p^0), \quad (18)$$

where $u_{Lh}(p)$ and $u_{Rh}(p)$ are LH and RH helicity state, $u_{LS}(p^0)$ and $u_{RS}(p^0)$ are chirality state in the rest frame, respectively. p^0 is the four-momentum in the rest frame. Consequently we have

$$(1+\gamma_5)u_{Lh}(p)=\sqrt{1+\beta}(1+\gamma_5)u_2(p^0), \quad (19)$$

$$(1+\gamma_5)u_{Rh}(p)=\sqrt{1-\beta}(1+\gamma_5)u_1(p^0), \quad (20)$$

where $u_2(p^0)$ and $u_1(p^0)$ are spin states in the rest frame, respectively. Substituting Eqs (19) and (20) into Eqs. (15) and (16), respectively, we obtain

$$\langle \boldsymbol{p}, h|S^{(2)}|\boldsymbol{p}, h\rangle = -i\frac{1}{8}(2\pi)^4\,\bar{g}^2\frac{1}{V}\frac{m}{E_p}\delta^{(4)}(0)(1\pm\beta)\;\bar{u}_s(p^0)(1-\gamma_5)\Sigma(p)(1+\gamma_5)u_s(p^0), \quad (21)$$

where plus sign refers to LH polarized fermions with $h=-1$ and $s=2$, while the minus sign to RH ones with $h=1$ and $s=1$.

To see the physical meaning of the $\langle \boldsymbol{p}, h|S^{(2)}|\boldsymbol{p}, h\rangle$, we note that for fermion weak self-energy transition process, generated by the interaction Hamiltonian density

$$\mathscr{H}_I^{\Delta m}(x) = -\Delta m \bar{\psi}(x)\psi(x), \tag{22}$$

the first order transition matrix element is given by

$$\langle \boldsymbol{p}, s|S^{(1)}|\boldsymbol{p}, s\rangle = -i(2\pi)^4 \frac{1}{V}\frac{m}{E_p}\, \delta^{(4)}(0)\bar{u}_s(p)\Delta m\, u_s(p). \tag{23}$$

For polarized fermions, according to Eqs. (17) and (18), we obtain

$$\begin{aligned} \bar{u}_{Lh}(p)u_{Lh}(p) &= \sqrt{1-\beta^2}\, \bar{u}_{L2}(p^0)u_{R2}(p^0) + \sqrt{1-\beta^2}\, \bar{u}_{R2}(p^0)u_{L2}(p^0) \\ &= \sqrt{1-\beta^2}\, \bar{u}_2(p^0)u_2(p^0), \end{aligned} \tag{24}$$

$$\bar{u}_{Rh}(p)u_{Rh}(p) = \sqrt{1-\beta^2}\, \bar{u}_1(p^0)u_1(p^0). \tag{25}$$

Thus Eq. (23) can be rewritten as

$$\langle \boldsymbol{p}, h|S^{(1)}|\boldsymbol{p}, h\rangle = -i(2\pi)^4 \frac{1}{V}\frac{m}{E_p}\delta^{(4)}(0)\sqrt{1-\beta^2}\, \bar{u}_s(p^0)\Delta m_h\, u_s(p^0). \tag{26}$$

Comparing the transition amplitude (21) with (26), we obtain

$$\Delta m(Z)_h = \frac{1}{8}\,\bar{g}^2\frac{1\pm\beta}{\sqrt{1-\beta^2}}(1-\gamma_5)\Sigma(p)(1+\gamma_5). \tag{27}$$

One can see that the self-interaction matrix element $\langle \boldsymbol{p}, h|S^{(2)}|\boldsymbol{p}, h\rangle$ amounts to a mass, i.e., the weak interaction mass caused by the neutral weak current.

Obviously, $\Sigma(p)$ is a divergent integral, as is easily seen by counting powers of k in the numerator and denominator of the integrand in Eq. (13). We will be forced to study their relative values for avoiding the troubles they cause. The relative ratio of the weak interaction masses for RH and LH polarized fermions is given by

$$\frac{\Delta m(Z)_{Rh}}{\Delta m(Z)_{Lh}} = \frac{1-\beta}{1+\beta}. \tag{28}$$

The weak interaction mass asymmetry of left-right handed polarized fermions is expressed by

$$A(m)^Z_{LR} = \frac{\Delta m(Z)_{Lh} - \Delta m(Z)_{Rh}}{\Delta m(Z)_{Lh} + \Delta m(Z)_{Rh}} = \beta. \tag{29}$$

3 The Weak Interaction Mass Caused by Charged Weak Current

The weak interaction processes may be caused by neutral or charged weak current. In above section we have treated the weak interaction mass caused by neutral weak current. In

this section we will treat the weak interaction mass caused by charged weak current in which a virtual intermediate particle is charged vector boson W.

The experiments and the theory have shown that neutral weak current is dominated by a coupling to both HR and RH chirality fermions and their weak coupling strengths are different, like Eq. (6), while charged weak current by a coupling to LH chirality fermions. The interaction Lagrangian density for charged weak lepton currents is given by [15]

$$\mathscr{L}_I^W(x) = \frac{g_2}{2\sqrt{2}}\, \bar{\psi}(x)\, \gamma_\mu\, (1+\gamma_5)\, \psi(x)\, W_\mu(x), \tag{30}$$

where $W_\mu(x)$ is the charged intermediate vector boson field. Obviously, it is completely similar to Eq. (9). Therefore, the relative ratio of the weak interaction masses for left-right handed polarized fermions is also similar to Eq. (28), i.e.

$$\frac{\Delta m(W)_{_{Lh}}}{\Delta m(W)_{_{Rh}}} = \frac{1-\beta}{1+\beta}. \tag{31}$$

The mass asymmetry of weak interactions caused by charged weak currents is expressed by

$$A(m)^W_{_{LR}} = \frac{\Delta m(W)_{_{Lh}} - \Delta m(W)_{_{Rh}}}{\Delta m(W)_{_{Lh}} + \Delta m(W)_{_{Rh}}} = \beta. \tag{32}$$

In conclusion, the weak interaction mass caused by neutral weak current possess is equal to that caused by charged one, namely, the weak interaction mass of LH polarized fermions is always greater than that of RH ones in flight with the same velocity in any inertial frame. Synthesizing Eqs. (29) and (32) the weak interaction mass asymmetry of fermions can uniformly be expressed by

$$A(m)_{_{LR}} = A(m)^W_{_{LR}} = A(m)^Z_{_{LR}} = \beta. \tag{33}$$

Comparing Eq. (33) with Eq. (3), we find out that the weak interaction mass asymmetry is similar to the lifetime asymmetry. It should be noted that $\Delta m(w)$ is a polarization-dependent relativistic mass. From Eqs. (28) and (31), the weak interaction mass can be rewritten as, respectively

$$\Delta m(w)_{_{Lh}} = (1+\beta)\; \Delta m(w) = (1+\beta)\; \gamma\; \Delta m(w)_0, \tag{34}$$

$$\Delta m(w)_{_{Rh}} = (1-\beta)\; \Delta m(w) = (1-\beta)\; \gamma\; \Delta m(w)_0, \tag{35}$$

where $\Delta m(w)_0$ is the weak interaction mass in the rest frame. As shown in Fig. 2, when $\beta \neq 0$, the weak interaction mass $\Delta m(w)_{_{Rh}}$ of RH polarized fermions is less than not only the weak interaction mass $\Delta m(w)_{_{Lh}}$ of LH ones but also $\Delta m(w)_{_0}$, and when the velocity approaches to light speed, $\Delta m(w)_{_{Rh}} \to 0$.

4 Neutrino Mass

There is a correlation between the mass of an elementary fermion and the relative strength of its dominant interactions. The mass of a hadron is mainly correlated with strong interactions and mass of a charged lepton electromagnetic one. All elementary fermions take part in weak interactions. Because the strength of weak interactions is much weaker than that of strong and electromagnetic interactions, the weak interaction mass is so small that it is unobservable and completely unimportant. However, the detection of the weak interaction mass is not

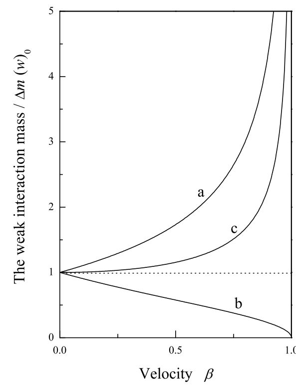

Figure 2: The weak interaction mass as a function of fermion velocity β. (a) The weak interaction mass $\Delta m(w)_{_{Lh}}$ of LH polarized fermions. (b) The weak interaction mass $\Delta m(w)_{_{Rh}}$ of RH polarized fermions. (c) The weak interaction mass $\Delta m(w)$ of unpolarized fermions.

absolutely impossible. Long lifetime K_L^0 meson and short lifetime K_S^0 meson, for example, have different masses and $\Delta m = m_{K_L^0} - m_{K_S^0} = (3.483 \pm 0.006) \times 10^{-6}$ eV [16]. K_L^0 and K_S^0 are not charge conjugate state, having quite different decay modes and lifetimes, so that, the mass difference Δm — but a very much smaller one — should be attributed to difference in their weak coupling. In accompanying with the progress of experimental technique and the improvement of the experimental accuracy, the detection of some extremely small effects would be becoming more and more possible. The measurement of neutrino mass is namely a very good example.

In the SM, neutrino mass must be zero. However, theoretically here is no compelling reason for massless neutrinos, and there exists already a vast literature on the extensional model of the SM containing massive neutrinos [17]. In recent years much of the effort of particle physical experiments has been devoting to the measurements of neutrino mass. The experiments of neutrino oscillation have proved that neutrinos assuredly have a very small mass [18, 19, 20]. It will radically alter our understanding of the violation of parity conservation law and implies physics beyond the SM of particle physics. Besides gravitational interactions, neutrinos only take part in weak interactions and thereby its physical mass is regarded as partly bare mass and partly weak interaction mass without strong and electromagnetic mass. It would be also entirely possible that a majority or all of the physical mass is the weak interaction mass. For neutrinos, therefore, the effect of the left-right asymmetry of the weak interaction mass would be very important. According to Eqs. (4), (34) and (35), the motion mass of a neutrino in flight can be written as

$$m(\nu)_{_{Lh}} = m(b) + \Delta m(w)_{_{Lh}} = \frac{m(b)_0}{\sqrt{1-\beta^2}} + (1+\beta)\frac{\Delta m(w)_0}{\sqrt{1-\beta^2}}, \tag{36}$$

$$m(\nu)_{_{Rh}} = m(b) + \Delta m(w)_{_{Rh}} = \frac{m(b)_0}{\sqrt{1-\beta^2}} + (1-\beta)\frac{\Delta m(w)_0}{\sqrt{1-\beta^2}}, \tag{37}$$

where $m(b)_0$ is the bare mass of a neutrino in the rest frame. One sees that the motion mass of LH polarized neutrinos is always greater than that of RH ones. Though neutrino has non-zero mass, its mass is so small that its velocity is very high and can even approach the speed of light. As shown in Fig. 2, therefore, the weak interaction mass does not contribute to the mass

of RH polarized neutrinos when $\beta \to 1$. The mass asymmetry of neutrinos can be expressed by

$$A(m(\nu))_{LR} = \frac{m(\nu)_{Lh} - m(\nu)_{Rh}}{m(\nu)_{Lh} + m(\nu)_{Rh}} = \beta \frac{\Delta m(w)_0}{m(\nu)_0}, \tag{38}$$

where $m(\nu)_0 = m(b)_0 + \Delta m(w)_0$, and $m(\nu)_0$ is neutrino mass in the rest frame. The mass asymmetry increases with the increase of neutrino's velocity and the ratio of $\Delta m(w)_0$ to $m(\nu)_0$.

The interaction mass is proportional to interaction strength. The relative strength of electromagnetic and weak interactions are 10^{-2} and 10^{-5}, respectively [14]. The ratio of electromagnetic mass to electron mass in the rest frame can be written

$$\frac{\Delta m(em)_0}{m(e)_0} \sim \frac{10^{-2}}{0.5\text{MeV}} = 0.02 \text{ MeV}^{-1}, \tag{39}$$

If electron neutrinos have 2 eV mass [21], then the ratio of weak interaction mass to electron neutrino mass in the rest frame can be written

$$\frac{\Delta m(w)_0}{m(\nu_e)_0} \sim \frac{10^{-5}}{2 \times 10^{-6}\text{MeV}} = 5 \text{ MeV}^{-1}. \tag{40}$$

Obviously, the contribution of the weak interaction mass to electron neutrino mass would be greater than that of electromagnetic mass to electron mass.

In the SM, neutrinos have only LH chirality states, antineutrinos have only RH chirality states. Note that what has been said here is chirality state, not helicity state. Taking out RH chirality states from Eqs. (17) and (18) we obtain

$$\frac{u_{Rh}(p)}{u_{Lh}(p)} = \frac{\sqrt{1-\beta}\, u^0_{L1}}{\sqrt{1+\beta}\, u^0_{L2}}, \tag{41}$$

then the ratio of the probability density is expressed by

$$\frac{\rho_{Rh}}{\rho_{Lh}} = \frac{u^+_{Rh}(p) u_{Rh}(p)}{u^+_{Lh}(p) u_{Lh}(p)} = \frac{1-\beta}{1+\beta}. \tag{42}$$

Obviously, RH helicity neutrinos will be present even though the RH chirality neutrinos are absent. However, the amount of RH polarized neutrinos is always smaller than that of LH ones in cosmos and its absolute value is also very small because neutrino's velocity approaches the speed of light. This means that though RH polarized neutrinos are present, not only their mass, but also their amount is extremely small. It might be the reason why we cannot observe RH polarized neutrinos experimentally.

It is well known that neutrinos play an important role in a number of astrophysical processes. There is strong evidence for the existence of a substantial amount of dark matter which is a mixture of cold dark matter (CDM) containing 70 % and hot dark matter (HDM) 30 % [22, 23]. Neutrinos, the dark-massive Dirac neutrino, might be the foremost HDM candidate [24]. Owing to the RH polarized neutrinos are quantitatively few and their mass is very smaller than the mass of the LH ones, hot dark matter, as one of leading source of the universe mass, might be nearly complete LH polarized. If this is true, then might HDM possess definite angular momentum in total effect? Could the angular momentum be responsible for part or all of the rotation of the galaxies, black holes and the universe? These questions have important consequences for the universe structure as well as evolution and need to be investigated further. Naturally, these are quite beyond the scope of this paper.

5 Summary and discussion

The experiments of SLD Collaboration and SLAC E158 Collaboration had proved that the integrated cross sections, caused by neutral weak current, do depend on the polarization of electrons. These experiments had indirectly demonstrated not only the lifetime asymmetry but also the asymmetry of the weak interaction mass. Therefore, we point out emphatically here that the idea of a mass asymmetry has already been linked to some experimental discoveries, and it is not merely a guess without justification.

Although the left-right asymmetry of the weak interaction mass is generally neglectable, it might have a great effect on neutrino mass because the dominant self-interaction of neutrinos is weak one. As see from Eqs. (36), (37) and (38), the motion mass of LH polarized neutrinos is always greater than that of RH polarized neutrinos which is almost unrelated to the weak interaction mass. In particular, when all of the physical mass of neutrinos is the weak interaction mass, the motion mass of LH polarized neutrinos can close to infinity but that of RH ones approaches to zero.

According to traditional conception, there is only a single fermion with a single mass and single overall lifetime. Now we might have to reconsider this perspective. Both the lifetime asymmetry and the weak interaction mass asymmetry are inevitable outcome of the parity nonconservation in weak interactions. Though the parity is space reflection symmetry, the space is closely related to the time, and thereby the parity is an attribute of space-time essentially. The phenomena of parity violation are experimentally exhibited the asymmetry of angular distribution in space, the lifetime asymmetry in time and the mass asymmetry as an effect of space-time. The three asymmetrical phenomena have described the parity nonconservation from all aspects of space-time. Although the mass asymmetry is quite small, it enables us to more profoundly cognize and understand the dynamical structure of weak interactions, the essence of the parity nonconservation as well as the characteristic of the space-time structure.

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